TITLE OF THE INVENTION

MANUFACTURING METHOD OF ROTOR CORE AND DEVICE USING THE SAME

BACKGROUND OF THE INVENTION

[0001]

The present invention relates to a rotor core or generator manufactured according to a manufacturing method of rotor core that comprises a generator rotor or a manufacturing method of generator, particularly to an AC generator for vehicle.

[0002]

An AC generator consists of a rotor comprising a rotor core, on which an exciting coil is wound, to be fixed around a rotary shaft facing each other and a stator comprising an annular stator core, on which a stator coil is wound, to be mounted facing the rotor at a clearance.

[0003]

The generator as above is designed to generate dielectric electromotive power in the stator coil but, when current is generated in the stator coil, magnetic flux is generated by the armature reaction.

[0004]

Due to the interaction between the magnetic flux caused by the armature reaction of the stator coil and that of the exciting coil of the rotor, a magnetic vibromotive force is generated between the stator and rotor.

It is well known that this force is transmitted to the structure, including stator core and bracket, and the vibration of the structure is then emitted as magnetic noise.

[0005]

In order to attenuate the magnetic noise, it is well known that, as disclosed in the Patent Document 1 (Japanese Patent Publication No. Hei 06-48897 (1994)) for example, a tapered surface is provided on the rear end in the rotational direction on the outer perimetric surface of a magnetic pole claw of the rotor core protruding in the same coaxial direction.

[0006]

Recently, for achieving higher output, it becomes popular to install permanent magnet between the magnetic pole claws of the rotor core mounted around a shaft facing each other. In order to hold the permanent magnet, it is well known that, as disclosed in the Patent Document 2 (Japanese Application Patent Laid-Open Publication No. Hei 09-98556 (1997)), a permanent-magnet fastener is provided on the inner perimetric end of the magnetic pole claw.

[0007]

[Patent Document 1]

Japanese Patent Publication No. Hei 06-48897 (1994)

[Patent Document 2]

Japanese Application Patent Laid-Open Publication No. Hei 09-98556 (1997)

SUMMARY OF THE INVENTION

[0008]

By the method according to the Patent Document 1, it is possible to attenuate noise while preventing the lowering of performance. However, there arises a problem that providing the tapered surface as disclosed therein requires a cutting process using a milling cutter, resulting in longer process time and also higher cost because cutting burrs need to be removed.

[0009]

Forming by forging may be a solution to the above. However, if the rotor core is formed by conventional extrusion forging by applying a press in the axial direction only, the material flow becomes uneven because the circumferential cross section of the magnetic pole claw is asymmetric, and hence higher load is needed for forming in higher accuracy, resulting in shorter life of the dies.

[0010]

It is popular that the fastener for holding the permanent magnet as disclosed in the Patent Document 2 is cut out on the inner perimetric end of the magnetic pole claw of the rotor core or formed in one-piece when the magnetic pole claw is formed.

[0011]

As explained above, the prior art in both Patent Documents is not only disadvantageous in view of the productivity but also weak in improving the production

accuracy because the tapered surface and the permanent-magnet fastener are formed separately.

[0012]

An object of the present invention is to offer a method of forming the tapered surface that is to be formed on the outer perimetric end of the magnetic claw of the rotor core and the permanent-magnet fastener that is to be formed on the inner perimetric end at the same time or in the same process.

[0013]

According to the present invention, while an intermediate blank having multiple magnetic pole claws that protrude in the same coaxial direction on a circumference and the inner perimetric surface of the magnetic pole claw are constrained by a die and a forming pressure is applied in a radial direction, the tapered surface on the outer perimetric end of the magnetic pole claw and the permanent-magnet fastener on the inner perimetric end are formed by forging at the same time or in the same process.

[0014]

According to the present invention, it is preferred that the tapered surface and fastener on one end are formed at the same time on the outer perimetric end in the same circumferential direction.

[0015]

According to the present invention, it is preferred that tapered surfaces and fasteners of the magnetic pole

claws are formed all together while the inner perimetric surfaces of all magnetic pole claws are constrained by a die at the same time.

[0016]

According to the present invention, it is preferred that the tapered surface and fastener are formed on each magnetic pole claw while the inner perimetric surface of each magnetic pole claw is constrained individually by a die.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an embodiment of an AC generator for vehicle that employs a rotor core manufactured according to the present invention

Fig. 2 is a horizontal cross-sectional view of an essential portion of Fig. 1

Fig. 3 is an oblique view of the rotor core of an embodiment manufactured according to the present invention

Fig. 4 is an oblique view of the intermediate blank of the rotor core of an embodiment manufactured according to the present invention

Fig. 5(a) is a cross-section of an essential portion of the magnetic pole claw 20a of the intermediate blank in a state just before being formed, and Fig. 5(b)is a vertical cross-section of an essential portion of the magnetic pole claw 20a of the intermediate blank in a state just before being formed.

Fig. 6(a) is a cross-section of an essential portion of the magnetic pole claw 2a of the rotor core in a state just after being formed, and Fig. 6(b) is a vertical cross-section of an essential portion of the magnetic pole claw 2a of the rotor core in a state just after being formed.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017]

An embodiment of the present invention is described hereunder, using Fig. 1 to Figs. 6(a) and 6(b).

[0018]

Fig. 1 is a vertical cross-sectional side view of an embodiment of an AC generator for vehicle that employs a rotor core 2 manufactured according to the present invention.

[0019]

A rotor 1 comprises a rotor core 2 fixed around a rotary shaft 6 and the rotor core 2 has an exciting coil 4, which is an electrically insulating bobbin on which insulation-coated conductor is wound in a number of turns, and the rotor 1 is rotated together with the rotary shaft 6. DC current is supplied to the exciting coil 4 via a slip ring comprising a brush 8 held in a brush holder and a brush ring 9 fixed on the rotary shaft 6, and magnetic flux is generated. Then, according to the number of poles, the rotor 1 excited by the exciting coil 4 generates N-pole and S-pole on a magnetic pole claw 2a of the rotor

core 2 in the circumferential direction of the rotor. In order to increase the magnet-motive force, a permanent magnet 3 is placed and fastened between the magnetic pole claws 2a of the rotor core 2.

[0020]

A stator 12 comprises a stator core 10 made of laminated steel plates in an approximately annular shape and a stator coil 11, which is a coil of insulation-coated conductor wound in a number of turns and embedded in a slot on the stator core 10.

[0021]

In short, in this generator, dielectric electromotive power is generated as the magnetic pole claw 2a of the rotor core 2 on which N-pole and S-pole are generated by the rotation of the rotor 1 interlinks with the stator coil 11, and DC current is outputted from the stator coil 11.

[0022]

Fig. 2 is a horizontal cross-sectional view of an essential portion of the rotor 1 and stator 12. The stator 12 has insulation-coated stator coils 11 embedded in the slots 10a provided on the stator core 10. While a permanent magnet 3 is mounted between the magnetic pole claws 2a, mounted to face each other, of the rotor core of the rotor 1, the permanent magnet 3 is covered with a protective cover 5 so as to prevent it form scattering around in case of crack or breakage. The permanent magnet 3 and protective cover 5 are prevented from moving

outwards in the radial direction due to a centrifugal force of the rotor 1 by a permanent-magnet fastener 2d that extends from the inner perimetric end 2c of the magnetic pole claw 2a in the circumferential direction. In addition, of the outer perimetric surface 2e of the magnetic pole claw 2a, a tapered surface 2f is so formed only on the outer perimetric end 2i at the rear in the rotational direction 13 that the clearance between the inside surface 10b and the outer perimetric surface 2e of the magnetic pole claw 2a is widened in order to attenuate the noise. This tapered surface may be a curved surface approximated to a taper.

[0023]

Fig. 3 is an oblique view of the rotor core 2 of the embodiment explained in Fig. 1 and Fig. 2. There are provided both the permanent-magnet fastener 2d, extending from the inner perimetric end 2c of the magnetic pole claw 2a in the circumferential direction, for preventing the movement outwards in the radial direction and the tapered surface 2f, formed on the outer perimetric end 2i on one end of the perimetric surface 2e in the circumferential direction, for attenuating the noise. The magnetic pole claws 2a are continued with each other by a plate section 2b.

[0024]

Steel material, made from magnetic substance of low carbon steel, suitable for rotor core of a DC generator is selected for the rotor core 2 and processed by cutting

- hot forging - cutting - lubrication - cold forging - cutting in this sequence to form an intermediate blank 20 shown in Fig. 4. And then, the permanent-magnet fastener 2d and tapered surface 2f are locally cold-formed on the magnetic pole claw 2a. 2g denotes the inner perimetric surface of the magnetic pole claw of the rotor core.

[0025]

Fig. 5(a) shows the cross-section of an essential portion of the magnetic pole claw 20a of the intermediate blank in a state just before being formed. Fig. 5(b) shows the vertical cross-section of the essential portion of the magnetic pole claw 20a of the intermediate blank in a state just before being formed. Fig. 6(a) shows the cross-section of the essential portion of the magnetic pole claw 2a of the rotor core in a state just after being formed. Fig. 6(b) shows the vertical cross-section of the essential portion of the magnetic pole claw 2a of the rotor core in a state just after being formed.

[0026]

The magnetic pole claw 20a of the intermediate blank as shown in Fig. 4, on which the inner perimetric surface 20g and inner perimetric end 20c of the magnetic pole claw 20a, the permanent-magnet stopper 20j on the end on which no taper is to be formed, and the plate portion 20b are all formed in finish dimensions, is mated with a fixed die 30 as shown in Figs. 5(a) and 5(b). The shape of the die is approximately similar to that of the inner perimetric surface 20g and inner perimetric end 20c of

the intermediate blank 20, and its dimensions is about the same as a finished one. The die comprises a bottom portion 30a that bears the pressure of the inner perimetric surface 20g of the magnetic pole claw 2a, side portion 30b that constrains the deformation of the inner perimetric end 20c, and forming portion 30c that bears the pressure of the fastener forming portion 20d and forms the permanent-magnet fastener 2d

[0027]

When a forming pressure 40 is applied in forming from Figs. 5(a) and 5(b) to Figs. 6(a) and 6(b), since the vertical cross-section of the magnetic pole claw 2a has a wedge shape, a component force 41 for moving the magnetic pole claw 2a along the bottom portion 30a of the die is generated. Accordingly, as shown in Fig. 5(b), a constraint force 42 has been applied beforehand from the direction of the plate portion 20b of the intermediate blank to fasten it. 2g denotes the inner perimetric surface of the magnetic pole claw of the rotor core.

[0028]

After fastening is complete, a forming pressure 40 is applied by a forming punch 31 from the direction of the outer perimetric surface 20e of the intermediate blank 20 so as to transfer the forming surface 32 of the punch and cause a local plastic flow to the outer perimetric end 20i of the magnetic pole claw 2a. Thus, the tapered surface 2f and permanent-magnet holder 2d are formed at the same time.

[0029]

In the above process, the material of the forming portion on the tapered surface 2f flows into an area left unfilled in the forging process of the intermediate blank 20, mating gap to the die 30, or outer perimetric surface 2e around the forming punch 31 although its volume is as small as 1.1% to 1.4% of that of the magnetic pole claw 2a. For the permanent-magnet fastener 2d, however, since it stretches in the circumferential direction as a result of being compressed thinner, it is recommended to adjust the fastener forming portion 20d in it volume on the intermediate blank 20. Otherwise, after forming is complete, it is permissible to trim off unnecessary portion of the permanent-magnet fastener 2d that has stretched in the circumferential direction. The bearing pressure of the forming punch 32 is about 90 kgf/mm^2 in average in this embodiment, which is satisfactorily within an allowable bearing pressure range for die steel. In addition, since plastic flow of the material is hardly caused on the surface of the die, seizure or similar trouble is hardly experienced, as a result of which satisfactory surface can be maintained on the die.

[0030]

According to the method as described above, it is possible to perform forming with superior forming accuracy, less stress and friction onto the die, and less problem on the die life as compared to the extrusion forming by applying a press in the axial direction only.

In addition, process time is shorter and no bur removal is needed as compared to the forming by cutting.

[0031]

Since, according to the present invention, the tapered surface to be formed on the outer perimetric end of the magnetic pole claw of the rotor core and permanent-magnet fastener to be formed on the inner perimetric end can be formed at the same time, product accuracy can be higher and mass-productivity be greater.